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**DEVELOPMENT OF MODIFIED
A/E37K-1 LOADING SYSTEM
WITH CAPABILITY OF LOADING/
RELOADING OF THE CBU-39/40
MUNITION**

J. Michael Beuerlein
Metric Systems Corporation

TECHNICAL REPORT AFATL-TR-68-49

APRIL 1968

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AIR FORCE ARMAMENT LABORATORY
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EGLIN AIR FORCE BASE, FLORIDA

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FOREWORD

This report covers work accomplished during the period October 1967 through December 1967 by the Metric Systems Corporation, 736 North Beal Street, Fort Walton Beach, Florida, under Air Force Contract No. F08635-68-C-0026, Project 8172, with the Air Force Armament Laboratory, Air Force Systems Command, Eglin Air Force Base, Florida. Mr. C. H. Anthony, Weapons Support Branch (ATZS), was program monitor for the Air Force.

The authors wish to acknowledge the contributions of Mr. B. Harris of Honeywell, Incorporated for his aid in supplying the prototype dispenser necessary for the development of this project; and Mr. C. H. Anthony and Mr. B. B. Armbrester of the Weapons Support Branch for their cooperation and close support in conducting operational tests of the loading equipment developed under this program.

All work performed was under the supervision of Mr. T. W. Horton, Director of the Aerospace Division of Metric Systems Corporation and Mr. J. M. Beuerlein, Project Engineer for the contractor.

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This report has been reviewed and is approved.


Roy. C. Compton
Acting Chief, Engineering Division

ABSTRACT

The purpose of this project was to develop, fabricate, and test a Loading System which would provide a loading/reloading capability for the CDU4/B/CDU5/B munition to the SUU-41/A dispenser and a further capability of preloading the CBU-39/40 munition onto Multiple and Triple Ejector Racks (MER's/TER's) used by the U. S. Air Force.

Drawings and specifications existed for a Loading System with a capability of preloading conventional iron bombs to MER's/TER's and with extensive modifications this system could be adapted to the SUU-41/A dispenser.

Several methods of mechanically performing the loading operation of the CDU4/B/CDU5/B munition to the SUU-41/A dispenser were explored. Different types of metals were investigated in order to obtain desirable characteristics with a maximum strength-weight ratio. The two-template method with alignment rods was considered to be superior to others tested, because of its reliability and relative simplicity

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SECTION I

MAJOR SPECIFICATION REQUIREMENTS

The following requirements are a part of the specifications of this development project:

1. Modify A/E37K-1 Loading System to provide a capability for:
 - a. Preloading the CBU39/40 munition onto multiple and triple ejector racks.
 - b. Loading the SUU-41/A dispenser with the CDU4/B and CDU5/B Canisters.

NOTE: SUU-41/A + CDU4/B/CDU5/B = CBU-39/40

2. Performance of the Modified A/E37K-1 Loading System shall:
 - a. Provide a capability for the loading of the canister to dispenser and preloading MER's/TER's on a production line basis resulting in a balanced work load between all operations.
 - b. Provide a capability for preparing 100 CBU-39/40 munitions in one 12 hour day.
 - c. Provide a capability for the loading of 10 canisters to the dispenser by two men in a period of six minutes.
 - d. Provide a capability for rotating the CBU-39/40 munition to a forty-five degree angle from the vertical and maintain this position until ejector rack lock-in is accomplished.

SECTION II
REDESIGN OF THE
A/E37K-1 LOADING SYSTEM

The basic A/E37K-1 Loading System was designed by the Air Force to provide a capability of preloading iron bomb type munitions onto ejector racks, thereby permitting pre-packaging of payloads in order to reduce aircraft turn-around time to a minimum. The introduction of a munition with a geometric cross-section of other than circular shape and of greater than normal length required certain modifications to this system.

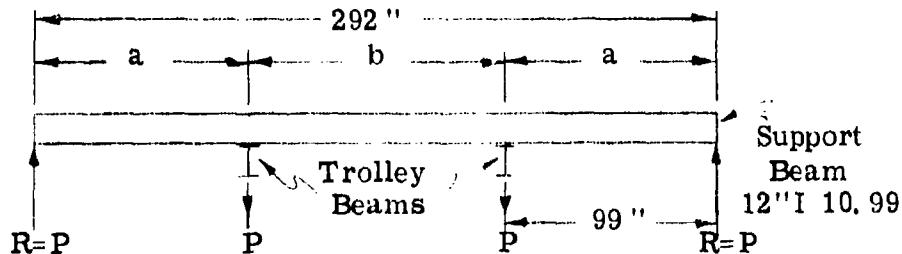
Modification 1

In preloading the CBU-39/40 Munition, certain mechanical and electrical functions must be performed from the top of the dispenser. An analysis of the operations to be performed showed that either the height of the overall conveyor system should be reduced or a raise walk-way be provided to permit proper access to the top of the dispenser for fastening and check out operations. From the safety viewpoint, it was determined to lower the entire conveyor system, including transfer and locator sections. No structural members were omitted in making this modification. Adequate reduction of height was obtained by reducing the length of the legs and relocating side piece and cross-tie members.

Modification 2

In order to handle the long profile of the SUU-41/A dispenser, it was necessary to increase the span of the 12" support beam by 42". Design criteria specifies a minimum safety factor of 1.5 yield strength for all load carrying members.

Maximum loading of trolley beams is to be 7, 500 lbs.



Minimum physical property of 6061T6 Structural Aluminum = 32, 000 pounds per in.² yield strength.

Moment of inertia for 12" I-beam at 10. 99 pounds per foot = 218. 1 in.⁴.

$$\text{Allowable moment} = \text{Allowable stress} \times \frac{I}{C}$$

$$M = S \frac{I}{C}$$

$$M = \frac{32 \times 10^3 \times 218.1}{6}$$

$$M = 1.16 \times 10^6 \text{ lb. in.}$$

For symmetrical loading shown above, the maximum moment occurs at either trolley beam and is equal to $P \times a$.

$$\text{Allowable } P = \frac{M}{a}$$

$$P = \frac{1.16 \times 10^6}{99}$$

$$P = 11,750 \text{ lb.}$$

The safety factor is equal to the allowable load divided by maximum rated loading of the trolley beam.

$$\text{S. F.} = \frac{11,750}{7,500}$$

$$\text{S. F.} = 1.57$$

From the above calculations it can be seen that at the specified rated capacity of 7,500 lb., a safety factor of 1.57 yield strength is present.



Figure 1. MERR/TER Loading Station

Item No.

- | | |
|---|--|
| 1 | 12" Support Beam (span of this beam was increased from 250" to 292") |
| 2 | 8" Trolley Beams |
| 3 | Conveyor Assembly Legs (length shortened approximately 5-1/2") |

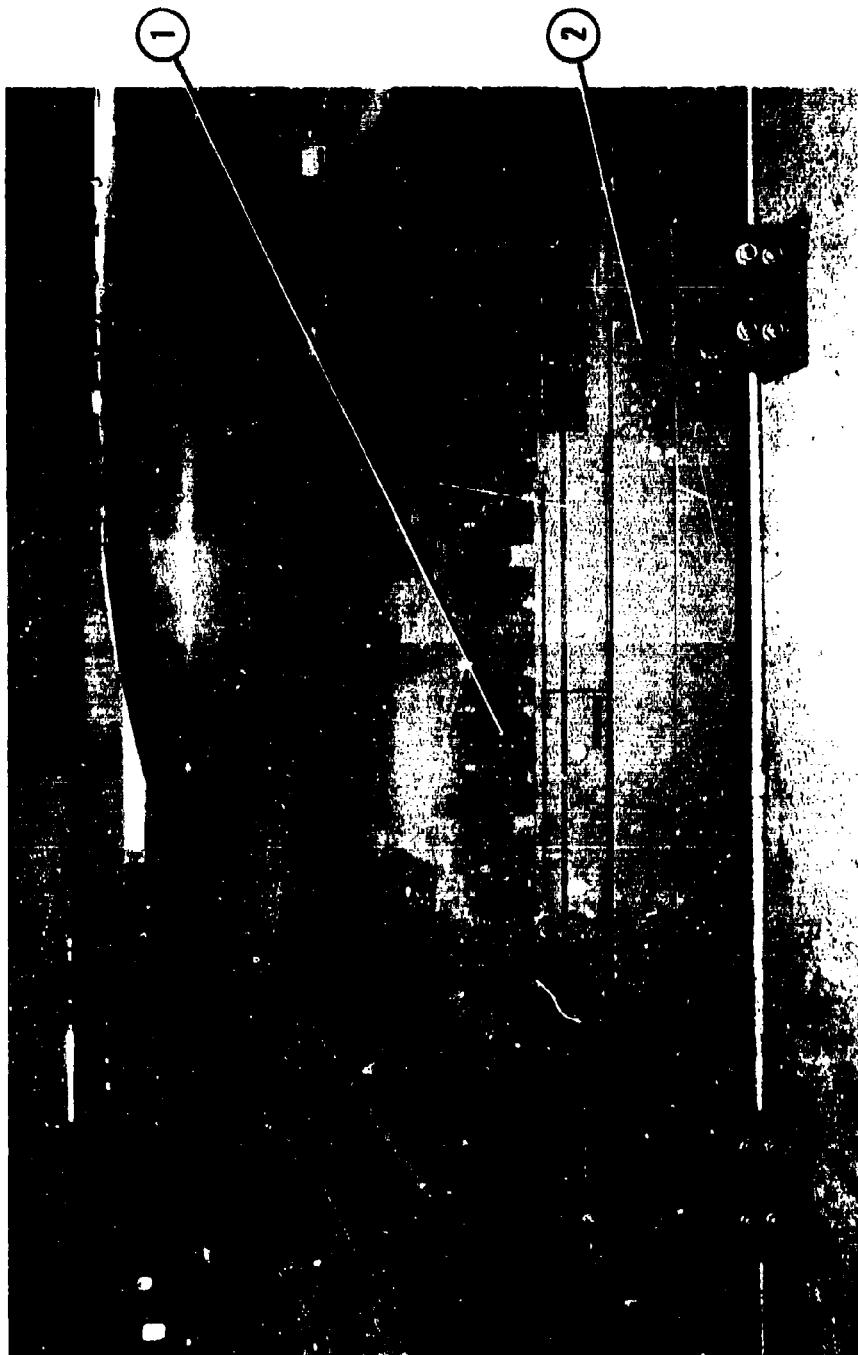


Figure 2. Special Transfer Section

Item No.

- | | |
|---|-----------------------------------|
| 1 | Special Transfer Section Assembly |
| 2 | Transfer Carrier Assembly |

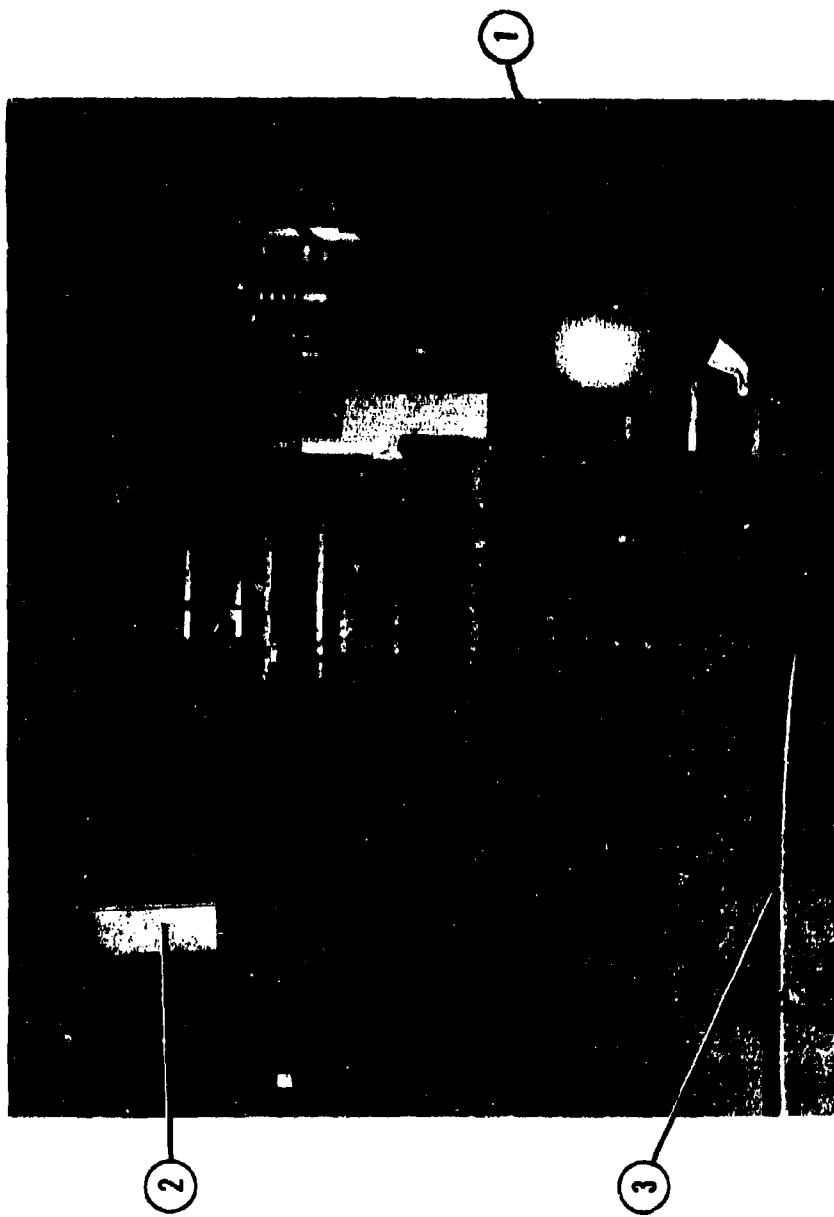


Figure 3. System Air Supply

Item No.

- | | |
|---|---------------------------|
| 1 | Air Compressor |
| 2 | Magnetic Starter |
| 3 | Quick Connecting Air Hose |

Modification 3

A special transfer section which will allow access to either trolley beam from either conveyor line was incorporated to permit greater flexibility of operations. This feature can also be used to balance loading operations from unbalanced conveyor line production. It is apparent that this item is necessary for smooth flowing operation of MER/TER loading procedure.

Modification 4

A compressed air facility was added to the system to provide motive power for pneumatic tools used in assembly and disassembly of munition items. An air compressor powered by a 3 HP electric motor furnishes air at 125 psi pressure through a piping system with quick coupler fittings spaced at 10' intervals. This compressor receives its power from the 3 ph 208 volt generator which is a part of the basic loading system. A separate magnetic starter was furnished to provide additional safety and flexibility to the air system. All connecting hoses are of the high volume, quick coupling type construction for ease of connecting and disconnecting during relocation operations.

The air pressure can be readily adjusted to any value up to 125 psi by adjusting the spring tension of the unloader assembly which is an integral part of the air compressor piping. A pressure setting of 90 to 100 psi is recommended for most small pneumatic tool operations.

SECTION III

DEVELOPMENT OF CANISTER LOADER

A critical operation necessary for the overall efficiency of the modified A/E37K-1 Loading System is the loading of the CDU4/B/CDU5/B canister assemblies to the SUU-41/A dispenser. A means of introducing and aligning ten canister assemblies to the dispenser simultaneously was considered necessary. Several methods for performing the critical stud alignment and electrical lead installation were investigated. For reasons of simplicity and reliability a template with 20 alignment rods was considered feasible.

This method incorporated an upper template with a hole pattern to match the dispenser hole pattern through which stainless steel rods are placed and attached to canister studs below. The bottom template has a grid pattern to match the openings in the bottom of the dispenser in which the 10 canister assemblies are positioned. By suspending the dispenser between the two templates and allowing it to descend over the canister assemblies, positive seating of all retention studs can be made.

All sliding rods are of stainless steel to reduce friction and provide maximum strength and corrosion resistance.

An electric hoist was selected over hand mechanical methods of raising and lowering dispenser because of ease and positive control features. It should be noted that a power supply is an integral component of this system.

The template and hoist is supported by an A-Frame type gantry which straddles the conveyor system and performs the loading operation over the conveyor assembly.

Retractile wire reels of stainless steel with small clips are used to insert wire leads from the canister assemblies. These reels provide a tension of 12 ounces to the electrical leads during the loading operation to prevent damage to connections.

It was necessary to utilize a second hoist and A-Frame assembly immediately following the canister loader to visually check all bottom covers for proper seating and installation of safety pallets. This A-Frame

assembly is identical to the A-Frame assembly furnished with the canister loader and all legs, braces and moving parts are interchangeable.

The design of the A-Frame gantry features pin connected leg assemblies of tubular aluminum for quick and easy assembly. The height can be quickly adjusted from a minimum of 5 feet to a maximum of 10 feet by means of the pin-connected telescoping leg assemblies. The overall weight of the gantry assembly is approximately 210 pounds. Rated capacity of the gantry at its maximum height is 1,500 pounds. By using the specified maximum loading value of 850 pounds a safety factor of 1.76 yield strength is provided.

The electric hoists which are used on both the canister loading A-Frame and the canister checkout A-Frame are of the same type and capacity. Lifting capacity is 2,000 pounds with a lifting speed of 8 feet per minute. The hoists are operated by a pushbutton type control which permits one hand operation and hairline control of the load. The load chain is of coil type construction. Chain containers are used to eliminate tail chain interference with load movements.

The electric hoists are suspended from a lightweight trolley assembly of 2,000 pound capacity. The trolley is attached to the I-beam of the gantry and secured by means of a special lock to prevent any movement.

An automatic limit stop is built into the hoist to prevent over-travel of the load chain in the upward direction. For safer operation the hoist includes a transformer which provides a voltage at the push-button control station of only 24 volts.

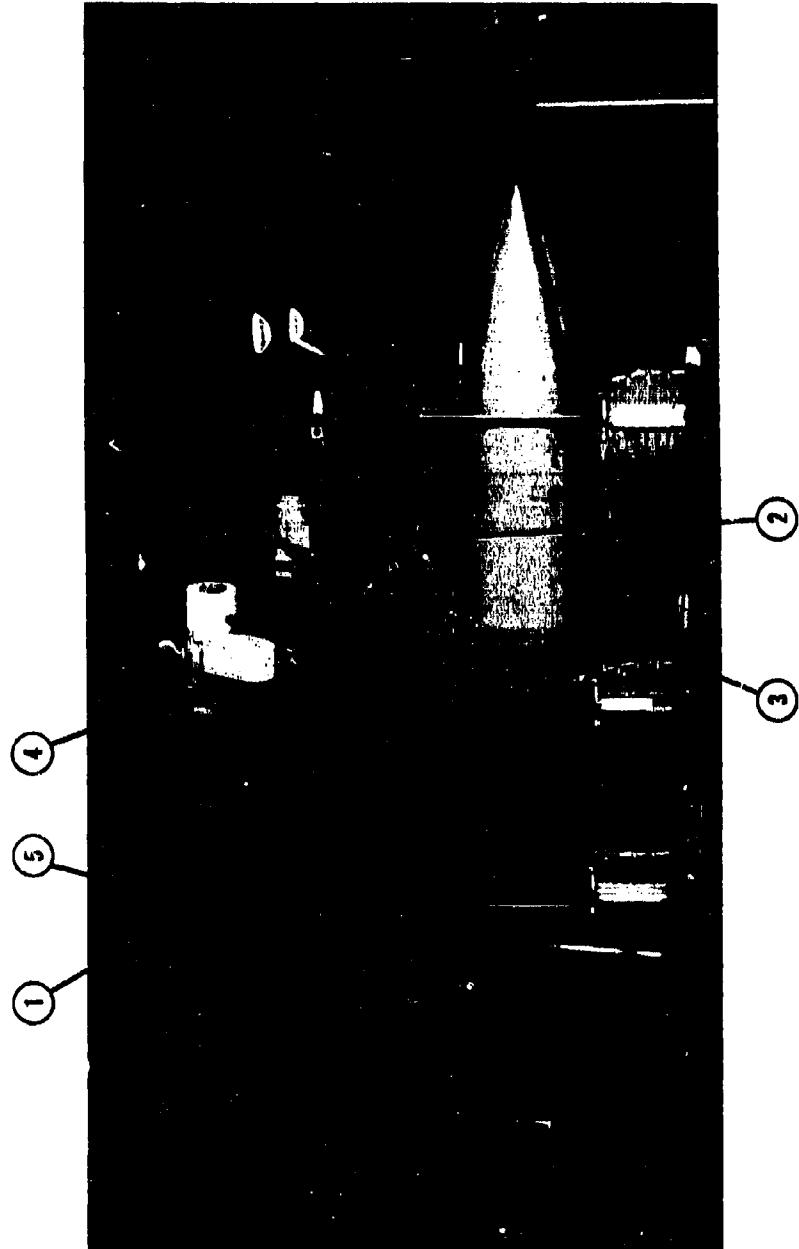


Figure 4. Canister Loading Assembly

Item No.

- | | |
|---|--|
| 1 | Canister Loader A-Frame Assembly |
| 2 | Top Template Assembly |
| 3 | Bottom Template Assembly |
| 4 | Electric Hoist with Pushbutton Control |
| 5 | Canister checkout A-Frame Assembly |

SECTION IV

DEVELOPMENT OF ROLL ADAPTER

To provide an interface between the flat bottom type munitions and the existing munition handling equipment required the introduction of an adapter assembly which, in effect, gives the dispenser munition a semi-circular cross section in the area that contacts the handling equipment. This adapter will permit up to 48° rotation of the munition in either clockwise or counter clockwise direction. Rotation of the munition is mandatory for shoulder station lock-in on the existing MER's/TER's.

Due to the fact that the center of gravity of the CBU-39/40 munition is about 1" above the center of rotation of the adapter and dispenser configuration, some means of locking the roll adapter against rotation during preliminary checkout and movement to the MER/TER loading area was necessary.

A modified bomb roller concept using a ratchet and pawl assembly was studied extensively. Also a strap arrangement including hooks and load binders was investigated. Since any strap or fastening device which would be placed across the top of the dispenser would interfere with access through the top covers, it was decided that the locking bomb roller would be the solution to the problem. The adapter rests on four bomb rollers, only two of which need be locked.

Since the center of rotation is within approximately 1" of the center of gravity, it is possible to orient the munition to any desired angle up to 48° from the vertical without the use of tools.

The adapters are constructed of high strength aluminum providing a maximum strength-weight ratio.

The modified bomb rollers have a knurled surface to provide an adequate friction coefficient between roller and roll adapter. The roller is keyed to roller shaft with two woodruff keys. A small 24 tooth ratchet gear was pinned to the roller shaft and its companion pawl was mounted on the roller bracket. The pawl is gravity operating and permits rotation in one direction only. The pawl can be disengaged easily by hand to obtain rotation in either direction.

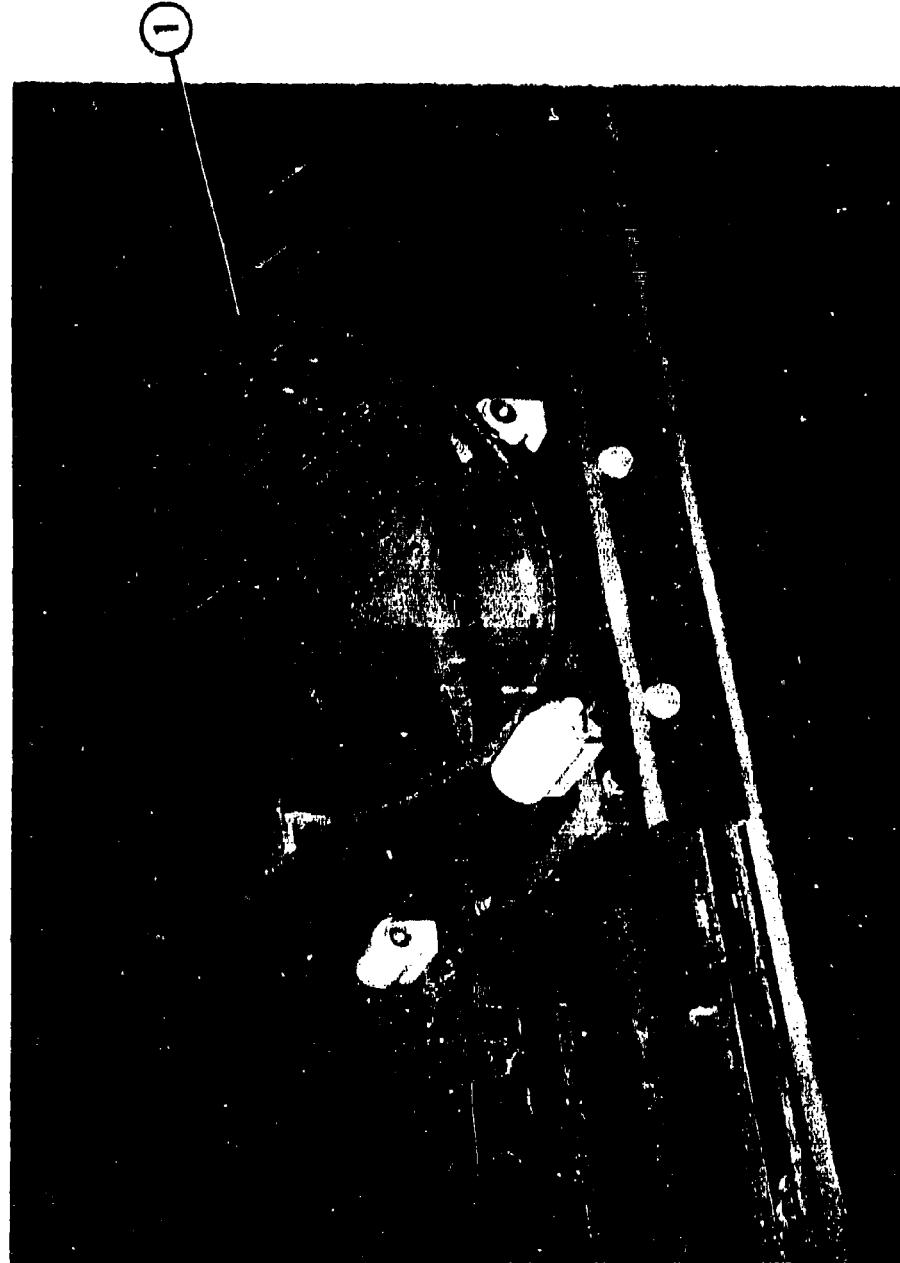


Figure 5. Roll Adapter Assembly, SUU-41/A

Item No.

1 Roll Adapter Assembly, SUU-41/A



Figure 6. Munitions Dolly

Item No.

- | | |
|---|--------------------------|
| 1 | Munitions Dolly Assembly |
| 2 | Standard Bomb Roller |
| 3 | Modified Bomb Roller |

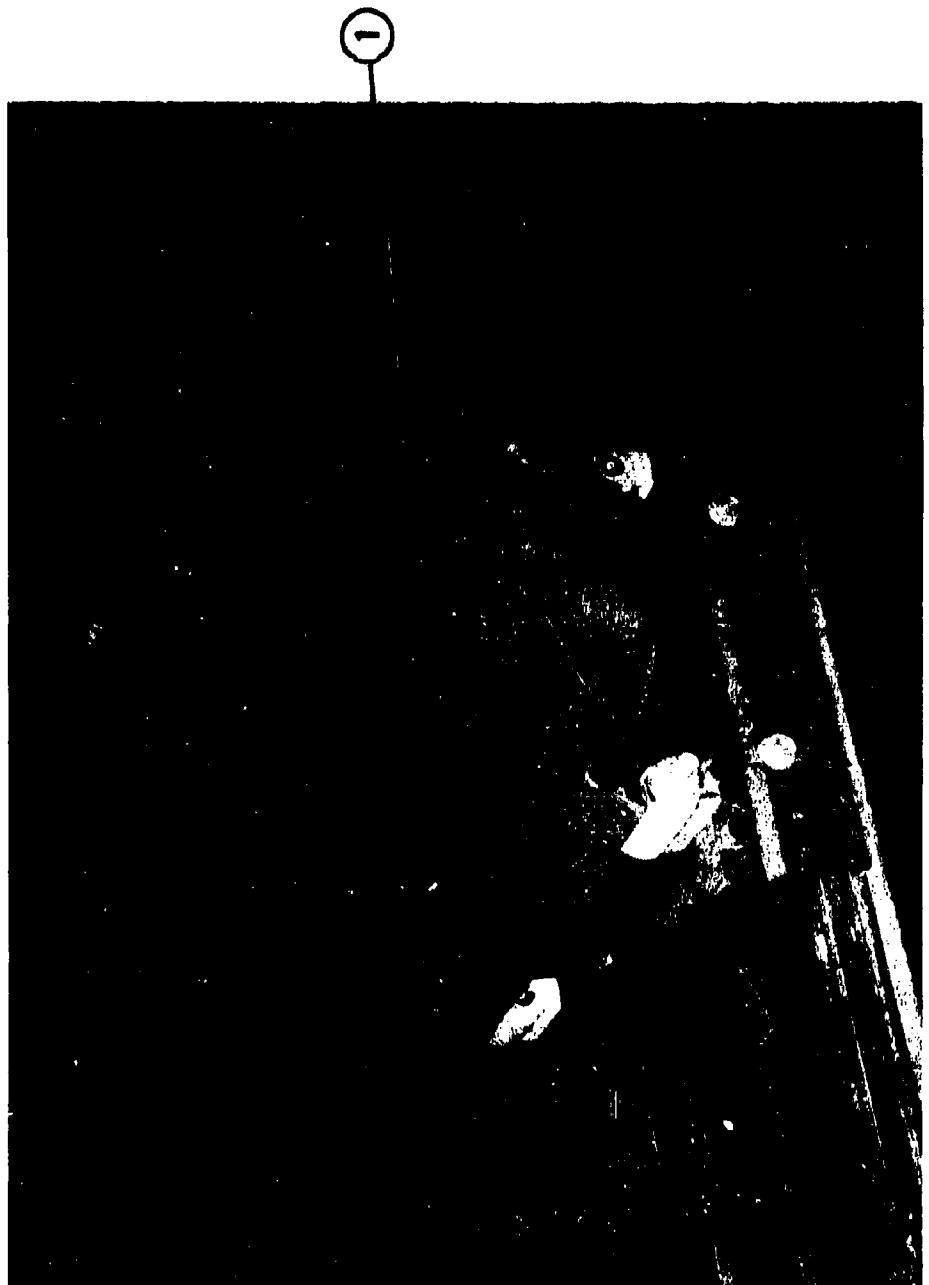


Figure 7. Roll Adapter, Tilted

Item No.

1

Roll Adapter at 45 degree angle for shoulder station lock-in

All parts of the bomb roller modification are of stainless steel or cadmium-plated steel. No lubrication should be required under normal operating conditions.



Figure 8. Modified Bomb Roller Assembly

Item No.

- | | |
|---|------------------|
| 1 | Knurled Roller |
| 2 | Ratchet Assembly |
| 3 | Pawl |

SECTION V

MAINTAINABILITY

The modifications to the A/E37K-1 Loading System are designed to require a minimum of maintenance consistent with reliability and performance of the system as set forth in the specifications. All like assemblies with like components bearing the same part number are completely interchangeable. The fasteners used in the assembly of component parts are Mil-Standard parts and items usually found within the government inventories. No parts or components are incorporated into the system which are not essential to the operation or structural strength of the completed assemblies.

The assemblies and components which have been added as modifications to the loading system are designed for rapid assembly and disassembly using a limited number of men. Where practical and where extreme tolerances are not required a locked pin connection is used for ease of alignment and assembly of the small gantries. The numerous guide rods employed in the canister loading operation are held firmly by the groove and retaining ring method rather than time consuming threaded fasteners. With exception of electric hoists and air compressors all moving parts are located in the open for quick and simple inspection and recognition of wear or potential failure. Periodic lubrication is required only on electric hoists, air compressors and generators. Moving parts of stainless steel require no lubrication but need be kept clean to prevent collection of dust particles.

All adjustment screws are positioned for quick access and easy adjustment. Height adjustments which may become necessary on the small gantries may be made easily without the use of tools. Pin connected telescoping legs can be adjusted by hand without disassembly or special tools. Height adjustments which may become necessary on the special transfer section added to the system can be made with the same tools necessary for adjusting the height of the basic conveyor section used throughout the loading system.

All assembly or disassembly operations for the entire loading system can be performed with general purpose tools available commercially. In so far as was practical the design of assemblies is symmetrical

about their centerline, thereby precluding the possibility of incorrect assembly.

Vendor's items consisting of electric hoists and air compressors and GFE Generators require periodic inspection and lubrication to ensure proper operation. Complete lubrication and maintenance manuals containing maintenance instructions and recommended lubrication schedules are furnished with each component. These manuals present the recommendations of the component manufacturer and are complete with assembly and disassembly instructions, operating instructions, and troubleshooting procedures. Data furnished by the manufacturer includes complete parts breakdown lists and instructions for obtaining replacement parts if necessary.

SECTION VI

CONCLUSIONS

The A/E37K-1 Loading System with modifications in its design has been erected and operationally tested at Eglin Air Force Base, Florida. These tests have shown that the modifications to the basic design have resulted in a conveyor system of optimum working height and exceptional ease of operation. With electric hoists to perform all lifting functions and compressed air facility to power tools for all fastening operations, an efficient, smooth-flowing production capability has resulted.

The clearances obtained by modifying the main gantry design appear to be quite adequate for personnel movement around the CBU-39/40 munition during loading operations.

The special transfer section which permits the loading of MER's/TER's from one or both conveyor lines increases the flexibility of the loading system. Unequal conveyor line production can be balanced at the rack loading station with the use of this item.

The air supply system consisting of an electrically-operated air compressor providing 11.2 cubic feet free air per minute will sustain 8 pneumatic tools operating full time. The demand for an estimated maximum of 12 pneumatic tools operating 50% of full time will fall well within the service range of this air compressor.

An evaluation of the performance of the CDU4/B/CDU5/B canister loader was made before delivery of this item with the canisters and dispenser furnished by the Air Force. Specification requirements spelled out a maximum loading time of 6 minutes using 2 persons for this operation. Successive tests showed that this operation can be performed in less than 5 minutes with 2 persons, using the production-type loader. The consensus of opinion formed during these tests is that no problem exists at this point in meeting production criteria as set forth in the specifications. Further tests were conducted by Air Force personnel after the system was set in operation at Eglin Air Force Base. These tests also produced loading times of less than 6 minutes.

The use of the adapter to establish an interface between the CBU-39/40 munition and standard munition handling equipment permits rotation of the munition to a forty-eight degree angle. No tools are necessary for this operation because of the proximity of the center of gravity of the munition to the center of rotation of adapter. The ratcheted bomb roller is hand operated and is capable of preventing rotation of the munition during make-ready operations. It will hold the munition in the desired 45 degree angle during ejector rack lock-in. The ratcheting device may also be removed and the roller used as a standard bomb roller.

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